SCIENCE

Friday, June 16, 1911

CONTENTS

The Spirit of Alchemy in Modern Industry: Professor Wm. H. Walker 913

Appropriations for the Department of Agriculture 918

Appropriations from the Bache Fund of the National Academy of Sciences 923

Scientific Notes and News 923

University and Educational News 926

Discussion and Correspondence:—
Vitalism and Experimental Investigation: Professor H. S. Jennings. *The Application of the Method of Least Squares:* Dr. Paul R. Heyl. *Dr. Brush's Theory of Gravitation:* Professor Fernando Sanford 927

Scientific Books:—
Hopkins on Soil Fertility and Permanent Agriculture: Professor F. H. King. *Wright's The Ice Age of North America:* Professor I. C. White 933

Special Articles:—
A Scale for Measuring the Merit of English Writing: Professor Edward L. Thorndike. *Sex-limited Inheritance and Sexual Dimorphism in Poultry:* H. D. Goodale .. 935

The North Carolina Academy of Science: Dr. E. W. Gudger 940

Societies and Academies:—
The American Philosophical Society 944

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of Science, Garrison-on-Hudson, N. Y.

THE SPIRIT OF ALCHEMY IN MODERN INDUSTRY

Never in the history of the world has there been such a time of intense human activity as the present: never a time of such gigantic undertakings, such marvelous achievements. Notwithstanding, the curve of progress is still an ascending one; although for some nations it has run paralel to its axis for many centuries, yet nowhere on the earth is there not at present a marked break in the line which for so long has represented a monotonous level in human affairs.

While there has been remarkable progress in ethics, culture and the fine arts, this world movement in human endeavor is epitomized in the expression "modern industry." Of the many factors which have entered into the advance in industry as a whole, possibly the most important is found in the manufacture and use of power. Where once we measured results by what a man could do, or later what a horse could do, now we measure the power at our command by thousands of kilowatts. We have had an age of steam, and we are passing through an age of electricity, and what next? Many think it will be an age of unprecedented chemical development. We have reason to be well satisfied with our present achievements; we do things so much more quickly and on so much larger a scale than our ancestors did. But at this enviable rate we can see the end of our resources—coal, timber, iron ore, are already measured in years. We must improve our present methods. We must inaugurate along every line of great endeavor a systematic search for new

truths, new light into the secrets of nature in order that we may live and work more efficiently.

It may seem a long step from a consideration of human dynamics at the intensity of the present, to the work of the alchemists of centuries ago, with all their magic and mysticism, their solitary lives and cherished secrets. But in reality there is something in common between these ancient investigators and the leaders in modern industry; and in looking ahead as to how we can best utilize the possibilities of the future we may learn something by considering the mistakes of the past.

The captains of industry and their army of co-workers are still alchemists at heart; they still strive to transmute the base materials of the earth into gold. But where the alchemist was satisfied only with seeing the noble metal glittering in his alembic, the modern business man is content in obtaining from his still a treasury certificate. It requires no magic philosopher's stone to effect a transmutation of paper into gold when once the former bears the proper inscription. Wherein have modern methods of alchemy changed from those of that eminent scholar who bore the name Phillipus Aureolus Theophrastus Bombastus von Hohenheim, and who lived and worked in the twelfth century and an account of whose checkered career has been handed down to us?

The spirit of alchemy is well represented in the word itself. It is an Arabic prefix, and the old Latin word for Egypt, meaning the dark, secret or hidden. It was the black art of the ancients. Another name sometimes used was "hermetic art," meaning also closed or sealed from view. The goal of those men from the gray of antiquity to the monks of the middle ages was the discovery of a way to make gold and silver from the metals already known, such as mercury and copper, tin and iron. We can see as we look back over their labors how now and again they received just the encouragement necessary to keep alive the embers of hope which glowed in each one's primitive laboratory. By melting the base metal copper with an earth which we now know carried arsenic, a silver white metal was formed; how easy to believe that this was an impure silver which needed but refining to be the longed-for result. When iron was left in a water solution of blue stone it disappeared and copper was found in its place. Surely this was a transmutation of iron and copper. Why not under proper conditions a further change of copper into gold?

But very many patient and able men devoted their lives to this fruitless search without material progress being made. The alchemists of Arabia and early Germany were little wiser than their predecessors of Egypt many centuries before them. The explanation of this lack of progress is to be seen in the profound secrecy which was at all times maintained. When some enterprising worthy did take it upon himself to transcribe for future generations his knowledge of the mystic art, his sentences were so ambiguous, and his diction so involved, as to make the whole entirely meaningless. Mysterious symbols were employed to render imitation the more difficult.

There was, therefore, no accumulation of knowledge or experience, and each succeeding investigator continued to grope in the darkness which had ever enveloped his calling, without deriving any benefit from the labor of either his predecessors or his contemporaries. The great and insurmountable obstacle to progress was nothing more than the jealous secrecy engendered by selfish competition. Both confidence and cooperation were entirely wanting.

Each one feared that his neighbor might profit by his experience were it to become known, never realizing that he must in the end get much more in return than he gave. There was but one of him, while there were many of his neighbors.

But in the thirteenth century there came a change. One Roger Bacon, who from his rare accomplishments and erudition was called Doctor Mirabilis, and who firmly believed in the existence of the philosopher's stone, was being tried at Oxford for sorcery. To disprove the charges against himself, he wrote a celebrated treatise with a long Latin name, in which he showed that phenomena which had been attributed to supernatural agencies were in fact due to common and natural causes. He pointed out further in his brief, a possible distinction between what he called theoretical alchemy, or work which could advance the knowledge of natural phenomena, and practical alchemy, or the striving after immediately usable information. He is to be regarded as the intellectual originator of experimental research, and by his generous treatment of the knowledge gained, gave to the movement the impetus for which it had so long waited. The limitations of this paper preclude my following in any detail the development of chemistry through the succeeding centuries, but it can be easily shown that just as knowledge was sought after for its own sake, and in proportion as there was free and honest intercourse between the investigators of the time, just so rapidly was real progress made.

The course of human events has been compared to a pendulum. We tend to swing to extremes; to go too far first in one direction, and then in the other, when real progress lies in the middle. The period of alchemy represents the pursuit of science for selfish and sordid ends; its sole object was that of making gold. The pendulum was at one extreme of its path. But at that time, as at this, the making of gold by whatever means did not in itself bring happiness or contentment, or even success. With the appearance of men who took an absorbing interest in the study of natural phenomena, for the purpose of gaining a deeper insight into the world around them, when investigations were undertaken from a desire to know, and to acquire knowledge which could become the property of the world at large, the pendulum began to move back.

For years the efforts of investigating minds were devoted to the explanation of the phenomena of nature; to the discovery of new laws and principles; to the accumulation and organization of facts, into what is called a science—to a real search for truth. This resulted in a general uplift of humanity, an advance in civilization, which can not be described or measured in words. It was a time when the human mind was struggling to determine realities in the midst of tradition and superstition; to realize that nature is always complex but never mysterious; that dependence should be placed in proven facts rather than the vagaries of priests and philosophers. Man became intellectually free.

But for many years after the broad generalizations upon which modern chemistry is founded were well established, industry did not profit much by scientific work. One hundred years ago the men who smelted the iron and copper, the lead and zinc, knew little of the principles underlying their practise. Leather was tanned, woolens and silks were dyed, porcelains and glass were made, without the aid of those who alone knew the chemistry involved. These were times when the advance in chemical knowledge was far ahead of the industries on the success of which

our material comforts depend, and which then stood in such need of help.

A rational attempt to apply chemical knowledge and methods to the industries commenced about 1850, and is in reality contemporaneous with the founding of the Institute of Technology which we to-day celebrate. It was in 1856 that Perkins made the first synthesis of a coal-tar color, and founded the industry which has become the most remarkable example of applied chemistry that we have. In 1855 Bessemer introduced his revolutionary process for making steel, made possible by the clear understanding of the nature of steel through improved analytical processes. With the founding of the Institute of Technology and other similar institutions, which not only did its part in advancing science, but taught its students how to apply this science to the problems of the day, our industrial progress has gone forward with leaps and bounds.

I would point out in passing that a great contribution in the aid of civilization is not necessarily made by the simple discovery of a scientific fact. Although, for example, the reactions underlying the ammonia-soda process were well known for many years, this knowledge did not benefit the world until the genius of Solvay made through it pure and cheap soda available. Cavendish long ago discovered that an electric arc produced nitric acid from the air; the world waited until a few years ago in order to profit by this knowledge, when the researches of Birkeland and Eyde made of the idea an industrial process. It was for this ability to apply scientific facts to the necessities of the times, that the world was looking at the time of the founding of the Institute of Technology. Much pure science we had, but it was as yet largely "uncontaminated by the worship of usefulness," if I may quote a contemporary. It was to just the kind of men which the Institute of Technology turned out—men who could appreciate the beauties of pure science, and at the same time had the ability to apply it, that our marvelous advance in material prosperity was due.

But to-day there can be seen evidences of a swing of the pendulum past the center, and again to approach an undesirable extreme. Research has become a word to conjure with. Private bequests for institutions of research in almost every field of science are made in units of millions of dollars. The most significant movement, however, is the very general establishment of laboratories for research, and especially chemical research, by great industrial organizations. This movement is but in its infancy, and it is here that a return of the old spirit of alchemy is to be feared. It has its foundation in the impatience of the more enterprising firms to wait for scientific facts and principles to be discovered by others; hence their willingness to appropriate often very large sums of money and to actively enter the field of what is called research in applied chemistry.

From what has already been said, there may appear to be a paradox in the expression "research in applied chemistry." How can the element of research enter into the work of applying to definite ends the facts already established as true by others? Is there a difference between research in so-called pure chemistry, and research in what, for want of a better name, we will call applied chemistry. Possibly I can make the distinction clear by a rough analogy. The development of research in a science may be compared to the exploration of a new country. New roads are to be laid out, tunnels bored and bridges built; in other words, new problems solved. This may be done in two ways. First, constructive work may be

undertaken wherever an interesting problem presents itself, without regard to whether there is a demand for such structure or not. It is built because of the interest of the builder in solving this particular difficulty, and the pleasure he takes in it, knowing also that some time it will be utilized. As a rule he is under no great pressure to get the structure completed. This may represent the method of pure chemistry, and the great advance in scientific knowledge of the past was made by boring just such tunnels and building just such bridges. The industries have used these structures when they could, or when some second builder could adapt them to use. Research in applied chemistry differs from that just described only in this—I should say, it *needs* differ only in this—that when a problem is to be solved, a bridge to be built, the work is undertaken at a point where there is a demand for its use; where people are waiting to cross over so soon as it is finished. The method of building is no different, the difficulties no less. The fact that the bridge is to be used makes the work of building no less dignified, nor is it possessed of less pleasure. In both cases the builder profits by all that has been done before, and contributes his bridge and the new materials of construction he may have found, to those who may come after him. To cite an example from experience, suppose I determine the electrical conductivity of metallic oxides at high temperature with great accuracy, and publish the results without reference to any particular application of the data. This is pure science. But suppose I am trying to perfect an electrical heating unit for high temperatures, and in insulating my resister I do this identical piece of work, namely, measure with great accuracy the electrical conductivity of metallic oxides at high temperature, and again publish the results. This is applied science. The work need not differ in the least degree. It can be as accurately done and the conclusions as scientifically drawn. The mere fact that the data will be used for some practical end need not make the work any less purely scientific.

Why then has research in pure chemistry commanded more respect than research in applied chemistry? Why did an eminent writer a few months ago lament the fact that there is not more research "uncontaminated with the worship of usefulness"? Why does usefulness contaminate? I think it lies in this: the investigator of pure science works in the broad daylight, throws his product open for inspection, and invites all to come and use it when they can. In applied chemical research the spirit of alchemy tends to creep in. The builder keeps his materials of construction, and his designs, a secret, and so boards up his bridge that those who cross over it can not see how it was built, nor profit by his experience. The moment a thing becomes useful we become jealous of its possession; we become narrow in our horizon; we sell our scientific birthright for a mess of potage; we become alchemists.

There is a heavy moral obligation on the part of large industrial organizations having fully equipped research laboratories, to contribute their share to the advance of the world's knowledge. They have well-stocked libraries, and are provided with all the current periodicals; they profit by all the scientific work which has been done and is being done. This is as it should be, and such firms are to be commended for their progressiveness. But is this not a reason why such laboratories should do their part in adding to the sum of available knowledge? There is in every laboratory much work which could be published and yet conserve the interests of the corpora-

tion. First there are the results which may not have proved valuable to the laboratory in which they were obtained, but which would be of immense value to some one else working in an entirely different field. Second, there are those results of value to the laboratory possessing them, but which could be published in an unapplied or "pure" form and which would make an important contribution to science and at the same time the publication would work no injury to the company or corporation most interested. And finally there are those results of operations and processes, machines and apparatus, which, if the truth were known, are possessed by a large number of concerns, but are held as valuable secrets by each. Every one would profit and no one be the loser by so farsighted and generous a policy. Germany is very justly held up before us as a shining example of marvelous industrial progress and prosperity. A very great deal of the credit for her present position is due to her splendid educational system. But no small factor in her national progress is the helpful attitude which her industrial organizations take toward the publication of scientific data. The individual does not suffer, while Germany both from a purely scientific and an industrial standpoint is rapidly advanced. But too often with us the president and his board of directors are alchemists; they fail to see why, if they pay the salaries of their research men, they should give to the public, or their competitors, any part of their results. They exclaim "what has posterity done for us?" They would have their laboratories remain the secret chambers of the alchemists, and continue to improve their methods of changing baser materials into gold without regard to the obligations which they owe to their fellows.

It requires no extensive mathematical calculation to prove that the manufacturers themselves would be the ones to profit by such a liberal treatment of the results of scientific work. Of one hundred manufacturing concerns each one would give but one per cent. of the whole contribution, while he would receive the remaining ninety-nine per cent. He could not in the long run be the loser. But of vastly more importance, he would feel and know that his organization was taking part in a world movement toward that increase of human knowledge upon which all real progress depends. Why become selfish and sordid so soon as one's scientific work becomes of immediate value to one's fellows? The greater sense of satisfaction, the greater success even of an industrial organization, lies in a fuller, freer, more generous publicity of the scientific results of their laboratories. Would that each such industry might benefit by the experience of Solomon, King of Israel, who, when asked, "What shall I give unto thee?" replied, "Give me knowledge and wisdom," and he was answered, "Wisdom and knowledge are granted unto thee; and I will give thee riches and wealth and honor."

Wm. H. Walker

Massachusetts Institute of Technology

APPROPRIATIONS FOR THE DEPARTMENT OF AGRICULTURE [1]

The growth of the National Department of Agriculture during the past ten years has far exceeded that of all of its preceding history. This was pointed out by Hon. Charles F. Scott, chairman of the House Committee on Agriculture, in submitting the new agricultural appropriation bill last winter. Its growth as marked by a decade has been phenomenal, viewed either from the standpoint of its scope and authority, its material resources, or its personnel.

[1] From the *Experiment Station Record*, April, 1911.